October through December, 1961

IBM Technical Papers Published in Other Journals

Amplifier for the Generation of Accurately Controlled Microsecond Pulses, J. B. Gunn, *The Review of Scientific Instruments,* **120,** No. 7, 804-807 (July, 1961).

A description is given of a pulse amplifier whose output voltage can be accurately controlled by the setting of a ten-turn potentiometer. The output amplitude and pulse lengths are variable up to 100 v, 2.6 amp, and 10μsec, respectively. An accuracy of 2 v is achieved, independently of external conditions, by the use of strong negative feedback to compare the output with a reference dc voltage. The various sources of error are discussed.

Atomic Wavefunctions for the Ground States of Na^+, Ne, and F^-, W. E. Donath, *J. Chem. Phys.,* **35,** No. 3, 817-820 (September, 1961).

Calculations of wavefunctions for the ^1S ground states of Na^+, Ne, and F^- which correlated essentially the outer shell are presented here. The "root" function is in each case an analytic Hartree-Fock function. The improved 13-configuration function yields an improvement in energy by about 50 per cent of the estimated correlation energy.

Bloch and Néel Walls in Thin Ferromagnetic Films, H. D. Dietze and H. Thomas, *Zeitschrift für Physik,* **163,** 523-534 (1961).

Domain walls in thin ferromagnetic films are associated with a stray field. This will have a strong influence on the structure and energy of such walls, as compared to bulk material. According to Néel, two different wall types exist in thin films. In this paper, Néel's estimation of the stray field energy is replaced by a consequent, variational treatment, and the structure and energy of a 180° domain wall in a thin film with uniaxial anisotropy is calculated.

Boundary-Layer Behavior in the Superconductor Transition Problem, Hirsh Cohen and W. L. Miranker, *Journal of Mathematical Physics,* **2,** No. 4, 575-583 (July-August, 1961).

A superconducting material may be isothermally transformed to a normal conductor by raising the magnetic field to a value greater than a certain critical field. When this is done, the transition takes place along an interface, determined by the critical field value and by a magnetic-flux condition. In the present paper, the effect on the transition rate of magnetic-field penetration into the superconductor is studied. This involves the solution of a free-boundary problem in which the free boundary divides two regions, each governed by a different parabolic differential equation. The problem is solved by using the asymptotic techniques of singular perturbation theory. A boundary layer is shown to exist along the moving interface on the superconducting side. The presence of the boundary layer slows the motion of the free boundary. Also included in the solution is a study of the effect of the magnitude of the initial field on the starting motion of the free boundary. Finally, some numerical results are presented.

Characteristics of the Annealing Kinetics of Tin Films Deposited at 88°K, J. Priest, C. Chiou, and H. L. Caswell, *Journal of Applied Physics,* **32,** No. 9 (September, 1961).

The electrical resistance of evaporated, high purity tin films deposited at 88°K decreases rapidly in two temperature regions as determined by isothermal annealing studies. One pronounced annealing peak occurs at 110°K and has an activation energy of 0.34 ± 0.06 ev. The second much less pronounced peak at 180°K has an activation energy of 0.74 ± 0.10 ev.

The annealing characteristics of five pure films varying in thickness from 960 A to 4100 A and a film deposited in a high partial pressure of N_2 are quite reproducible. The presence of O_2 during evaporation, however, drastically altered the annealing kinetics and increased the activation energy at any given temperature. The defect resistivity at the time of evaporation was the same for all five pure films and a film deposited in a high partial pressure of N_2, but is about 75% higher for the film deposited in the presence of O_2.

Circuit Simulation by a Direct Approach, R. W. Boucher and C. T. Lecher, *Instruments and Control Systems,* **34,** No. 6, 1091-1095 (June, 1961).*

The article describes how the use of an analog computer can be more convenient than the use of a bread-board for the simulation and study of circuits and their components.

*For period April through June 30, 1961.

A Computer Program for the Synthesis of Combinational Switching Circuits, R. M. Karp, F. E. McFarlin, J. P. Roth, and J. R. Wilts, *Proceedings of the Second Annual Symposium and Papers from the First Annual Symposium on Switching Circuit Theory and Logical Design* (AIEE), **S-134,** 182-195 (September, 1961).

This paper describes an IBM 7090 program for the design of single-output combinational switching circuits for arbitrary sets of primitive logical elements. The only restriction on circuit configurations is that no feedback loops may occur. The procedure is an outgrowth of one given by Roth. The decomposition techniques are generalizations of those discussed by Ashenhurst.

Given a function $F(A, B, C)$, where A, B, and C are states of binary variables and F may have "don't care" combinations, a representation of the form $F = G[\alpha(A, B), B, C]$ is called decomposition of F. Any loop-free circuit can be described by a sequence of decompositions. Efficient procedures for the detection of decompositions are given in terms of a convenient normal-form representation of switching func-

tions. Simplifications obtained by considering only the subclass of so called vertex-functions are discussed. The program carries out a systematic search through the admissible sequences of decompositions, using a lexicographic ordering, designed so that the most promising sequences are investigated first. Several further refinements are used to limit the search. The calculation yields a list of successively improved implementations, eventually including one of minimum cost. Examples are given of several circuits of minimum or near minimum cost derived by the program.

Concerning the Theory of Anisotropic Magnetization, S. H. Charap, *J. Phys. Chem. Solids,* **16,** Nos. 3/4, 315-316 (August, 1961).

The calculation by Callen and Callen* of the anisotropic magnetization is shown, by a spin wave analysis, to be valid only in the case of large applied fields.

*E. R. Callen and H. B. Callen, *J. Phys. Chem. Solids,* **16,** 310 (1960).

Designing Diode-Inverter Transistor Logic Circuits, Richard B. Hurley, *Electronic Equipment Engineering,* **9,** No. 8, 55-58 (August, 1961).

Step-by-step procedure simplifies design of diode-inverter logic circuits. Combination of passive diode logic circuits with a transistor (for powering) provides the basis for a large variety of diode-transistor switching circuits. Design details are given for a typical circuit.

Development of a Technical Services Department in IBM, Frank H. Welsh, Jr., *IRE Transactions on Engineering Management,* **EM-8,** No. 3, 139-142 (September, 1961).

It is necessary to provide research and engineering personnel developing highly complex products with an array of specialized supporting services. Since these supporting skills are not required by any one engineering group 100 per cent of the time, economics dictates that these services be centralized. The supporting skills may vary from the analytical ability of theoretician to the manipulative ability of a tool and die maker.

In this article, it is not possible to report the development of technical services in all IBM laboratories. Therefore, the discussion is limited to the IBM General Products Division Development Laboratory at Endicott, N. Y.

Dielectric Properites of $BaTiO_3$ Single Crystals in the Paraelectric State from 1 kc/sec to 2000 Mc/sec, E. Stern and Allen Lurio, *The Physical Review,* **123,** No. 1, 117-123 (July 1, 1961).

The dielectric constant of $BaTiO_3$ single crystals in the region above the 120°C Curie point has been measured at several frequencies in the range from 1 kc/sec to 2000 Mc/sec. In addition, the B coefficient in Devonshire's equation for the free energy has been studied at 500 Mc/sec. It is shown that the crystal is completely clamped with respect to the measuring field at 500 Mc/sec so that the coefficient of the P^4 term in Devonshire's equation is positive and agrees with the expected theoretical result of $B_F^C = 2.23 \times 10^{-13}$ cgs unit.

The Dissociation Pressure of GaAs, V. J. Lyons and V. J. Silvestri, *Journal of Physical Chemistry,* **65,** 1275-1276 (January, 1961).*

Gallium arsenide thermally dissociates to the constituent elements. The dissociation pressure has been measured over the temperature range of 1051-1196°C by observing the arsenic dew point. In this temperature range the data may be represented by the equation $\log P_{mm} = -\frac{34500}{T_{0K}} + 25.8$. The measured pressures and the values of the equilibrium constant for the reaction $As_4 \rightleftarrows 2AS_2$ were used to calculate the pressure of each species in equilibrium with solid GaAs.

*For period January through March 31, 1961.

The Distribution of Quadratic Functionals, J. B. Thomas* and E. Wong,* *Quarterly of Applied Mathematics,* **19,** No. 2, 150-153, (July, 1961).

The distribution of quadratic functions involving Gaussian processes is considered. The problem is shown to reduce to that of solving a homogeneous matrix integral equation. This result extends the earlier work of Siegert.

*Princeton University, Princeton, New Jersey.

Effect of Temperature on the Exoemission of Electrons from Abraded Aluminum Surfaces, W. T. Pimbley and E. E. Francis, *Journal of Applied Physics,* **32,** No. 9, 1729-1733 (September, 1961).

A model and resulting theory for the exoemission of electrons from metal surfaces are presented. The model states that the exoemission is governed by the diffusion of vacancies in the metal, vacancies created by the abrasion. A vacancy, upon diffusing to the surface, may give up its energy to an electron. However, when in the same event, a photon also transfers its energy to the electron, the electron may be emitted. Experiments performed show the exoemission decay to be composed of two exponential decays. Both exponential decay constants vary with temperature according to the equation, $k = Fe^{-E/RT}$. Here, F is a constant and E is an activation energy which, measured, approximates 5.6 kcal/mole. A comparison between experiment and theory give the theory corroboration.

Effect of Ultrasonics on Natural-Convection Cooling Systems, J. H. Seely, *Electro-Technology,* **68,** No. 3, 12 (September, 1961).

Ultrasonic agitation of liquid coolants shows promise of increasing the rate of heat transfer from electronic components immersed in the coolant. In an investigation of the effects of ultrasonic vibration, a heated wire was cooled by natural convection in five liquids; cooling curves for each were then plotted with and without ultrasonically induced cavitation. The results indicated that ultrasonic vibration increases heat-transfer rate in a natural-convection cooling system.

Electroluminescent-Photoconductive Pattern Recognizer Organizes Itself, J. A. O'Connell,* *Electronics,* **34,** No. 28, 54-57 (July 14, 1961).

Recent interest in electroluminescence and photoconductivity has led to the development of a new class of logical devices. Many conventional logic devices, including rings and shift registers, have been transformed directly to EL-PC counterparts, with emphasis on combinational circuits. This article describes EL-PC elements used in a developmental self-organizing pattern recognizer, based on the flow-table logic concept. The pattern recognizer works on stepping or shift-register principles using photoconductors and electroluminescent cells as active elements. An "ON" condition is stepped

from stage to stage when the digital information presented to it matches a pattern of binary words it has been programmed to accept. Procession of the "ON" condition to the output stage indicates pattern recognition.

*Present address: General Telephone & Electric Co., Inc. This work was done while he was with the IBM Development Laboratories, Poughkeepsie.

Electrolyte Solutions, Harold L. Friedman, *Annual Reviews of Physical Chemistry,* **12,** 171-194 (1961).

A critical review of the literature, mostly for 1960.

Emission Control for the Omegatron Type Mass Spectrometer, G. R. Giedd and G. C. Roberts, *Journal of Scientific Instruments,* **38,** No. 9, 361-362 (September, 1961).

The basic circuit usually used with the omegatron provides no method of regulating filament emission to maintain constant target or beam current. In operation, the basic circuit permits emission current variations of as much as $\pm 40\%$, together with long term electrometer drift of $\pm 15\%$, at an input impedance of 10^{10} ohms. A circuit of the type used for emission regulation of ion gauges is modified to provide closed-loop feedback control of omegatron filament emission. Use of this circuit, which monitors and controls the target current, results in emission control of $\pm 3\%$ and reduces long-term electrometer zero drift to $+5\%$.

Epitaxial Vapor Growth and Doping of Germanium by a Germanium-Iodine Reaction, J. C. Marinace, W. E. Baker, and D. M. J. Compton,* *Conference Proceedings, Metallurgy of Elemental and Compound Semiconductors,* Interscience Publishers, New York, 271-283 (1961).

The Ge-I_2 disproportionation reaction in a sealed tube will deposit at 400°C, epitaxially upon germanium seeds, germanium of a purity comparable to the best melt-grown germanium. The amount of iodine incorporated is low, electrically inert and fixed in the lattice. Suitable impurities may be incorporated, donors more readily than acceptors. The solubility of one impurity (Au) is greater than that at equilibrium. The incorporation of impurities is a rate process. The deposition process is modified to deposit successive *n*-type and *p*-type layers. The *p-n* junctions formed compare favorably with those fabricated by other means.

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Ethion – P_2^{32}, S. E. Forman* and B. L. Gilbert, *Agricultural and Food Chemistry,* **9,** No. 4, 260-262 (July/August, 1961).

The insecticide, O, O, O′, O′-tetraethyl S, S′-methylene bisphosphorodithioate-P_2^{32} (ethion P_2^{32}) was synthesized for use in biological studies. The product was obtained in a radiochemical yield of 33% from 3 curies of $H_3P^{32}O_4$. Its vapor pressure was determined by a Knudsen effusion method. At 25°C the vapor pressure was 1.5×10^{-6} mm.

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Exact Wave Functions in Superconductivity, Daniel Mattis and Elliott Lieb, *The Journal of Mathematical Physics,* **2,** No. 4, 602-609 (July-August, 1961).

The ground-state wave function and some of the excited states of the BCS reduced Hamiltonian are found. In the limit of large volume, the boundary and continuity conditions on the exact wave function lead directly to the equations which Bardeen, Cooper, and Schrieffer found by a variational technique. It is also shown in what sense the BCS trial wave function may be considered asymptotically exact in this limit. Finite-volume corrections are included in an appendix, and explicit calculations are carried out for a one-step model of the kinetic energy which has possible applications to the problem of the finite nucleus.

A Fast Binary Counter, E. Taranto, *J. Brit. IRE,* **22,** No. 1, 31-33 (July, 1961).

A transistor binary counter employing seven flip-flops is described. Its operation is dependent only on the switching time of one flip-flop, which may be ~ 100 ns.

A 4-Megacycle 24-Bit Checked Binary Adder, M. E. Homan, *Communication and Electronics,* **56,** 443-450 (September, 1961).

The logical design of a 24-bit binary adder applicable to STRETCH-type computers is described. Solid-state, nanosecond logical elements employing diffused-junction transistors are used in current-mode and emitter-follower configurations. Parallel carry generation and preformed sum-selecting functions for four-bit subgroups are utilized for maximum speed. The higher component count is more than offset by the increased performance over adders of more conventional design.

Guided-String Cutter for Single Metal Crystals, Alan R Wayson, *Review of Scientific Instruments,* **32,** No. 8, 967-971 (August, 1961).

A guided string acid saw for the strain-free planar cutting of oriented single crystals is described. A Saran monofilament used as the acid carrying element is guided completely through the cut by a grooved blade serving the threefold purpose of guide, pressure device, and follower for a position sensing mechanism which automatically controls the feed. Guiding of the string results in a width of cut to string-diameter ratio considerably lower than that of unguided acid saws. Bismuth and copper crystals have been cut with excellent results using this device.

How to Save on Drawings for Modular Electronic Equipment, G. W. Allen, *The Magazine of Standards,* **32,** No. 8, 228-232 (August, 1961).

A particularly noticeable trend in electronic manufacture and design in the past few years has been to design electronic equipment in modular form. A drawing system similar to the one presented in this article has reduced substantially the number of pictorial drawings required for a computer system designed by IBM at Kingston, New York, and has proved practical for use in day-to-day engineering.

In order to accomplish this reduction in the number of pictorial drawings and maintain complete engineering data, a new system of drawing organization is used.

Impurities in III-V Compounds and Mutual Solubility of III-V Compounds, K. Weiser, *Metallurgy of Elemental and Compound Semiconductors,* **12,** 371-378 (1961).

Semiquantitative comparisons are made of the distribution coefficients of impurities in germanium or silicon and those of the corresponding impurities in III-V compounds. An explanation is offered to account for the widespread miscibility of III-V compounds as compared to the limited mis-

cibility among group IV elements. A discussion of the amphoteric behavior of group IV elements in some III-V compounds as a function of doping level is presented.

Indirect Exchange Model for Ferromagnetic Metals, S. H. Liu, *The Physical Review,* **123,** No. 2, 470-474 (July 15, 1961).

The ferromagnetic properties of rare-earth metals and their alloys are discussed in terms of the indirect exchange model. It is shown by the molecular-field approximation that, in calculating the Curie temperatures of these metals, the simple theory of Fröhlich and Nabarro and Zener is applicable. The second-order energy terms calculated by Ruderman and Kittel, Kasuya, and Yosida are important in discussing the low-temperature properties. Some numerical results are obtained which are in good agreement with the experiments.

The Influence of Demagnetization and Anistropy Energy on Bloch Wall Thickness and Coercive Force in Thin Films, R. E. Behringer* and R. S. Smith, *Journal of the Franklin Institute,* **272,** No. 1, 14-22 (July, 1961).

A reasonable approximation is made to the actual Bloch wall structure in thin uniaxial magnetic films. The corresponding demagnetization, exchange, and anisotropy energies are calculated and the Bloch wall thickness is determined by minimizing the wall energy. The result is used to determine the functional relation between coercive force and film thickness on the surface roughness model of Néel. Results show that the inclusion of the demagnetization energy by the crude model of Néel is, in fact, a very good approximation. The inclusion of negative effective anisotropy leads to deviations from the four-thirds power law.

*San Fernando Valley State College, Northridge, California.

Influence of Thiourea on the Deposition Reactions of Iron and Nickel, Richard D. DeMars, *Journal of the Electrochemical Society,* **108,** No. 8, 779-782 (August, 1961).

The deposition reactions of iron and nickel were studied polarographically in solutions containing the metal ion and potassium chloride and the metal ion, potassium chloride, and thiourea. Analysis of the polarographic waves using Koutecky's method yielded values for the kinetic parameters, αn_a and $k^0_{f,h}$, for the reduction reactions. The effect of temperature and thiourea concentration on these parameters was studied. These results can lead to qualitative predictions about the composition of films plated from similar solutions. The value of such predictions for the case of the plating solutions studied is illustrated by a series of plated iron-nickel films.

Lateral Vibrations of a Beam under Initial Linear Axial Stress,* Yih-O Tu and George Handelman,** *Journal of the Society for Industrial and Applied Mathematics,* **9,** No. 4 (September, 1961).

Various approximate methods for the eigenvalue problem of lateral vibrations of a beam under initial axial stress are considered. These include the perturbation method for small initial stress and singular perturbation method for large initial stress. Bounds of eigenvalues may be found by the Schwarz iteration method and variational principles. Lower bounds for the first eigenvalue may also be obtained by appropriate comparison theorem or Southwell's method established according to the form of initial stress. Results are compared numerically for the case of linear axial stress.

*This work has been supported by the Air Force Office of Scientific Research of the Air Research and Development Command.

**Department of Mathematics, Rensselaer Polytechnic Institute, Troy, N. Y.

Logic and Timing in Digital System Design, J. Earle, *Electronic Design,* **9,** No. 18, 30-41 (August 30, 1961).

Digital systems are designed on roughly three levels. The basic building blocks are standard logic circuits that (except for a few nonlogical elements, like drivers) mix digital input signals and quantize the result in a way which can be expressed by a Boolean logic function. Networks called combinational logical circuits constitute the first level of digital design; those called sequential circuits, the second level. At the third level of digital design, the designer organizes logic networks into a sequential system to perform the required system functions. On each level the designer makes basic choices which relate to all levels. An understanding of these choices and their interrelationships is essential to any comprehensive digital-design effort. The article discusses circuit logic, sequential circuits (synchronous and asynchronous), and sequential systems (synchronous, asynchronous, and mixed).

The Logic Potential of Molecular Electronics in the Multicollector Transistor, J. Earle, *Electrical Engineering,* **80,** No. 7, 525-533 (July, 1961).

In this article, means of using the phenomena of molecular electronics to perform logic are explored. Emphasis is on the 2-collector transistor, with occasional indications of the logical effects of more collectors.

Low Friction Coatings with Good Bond Strength, J. E. Brophy, R. W. Ingraham, and C. Pettus, *Materials in Design Engineering,* **54,** No. 3, 10-11 (September, 1961).

The technique of coating materials with molybdenum, tungsten, sulfur, and selenide lamellar films is discussed. Such coatings are particularly suitable where long lubrication life is required, and where the parts are located in an inaccessible area. The technique is applicable to conductive base metals such as steel and copper. A description of the process is given, and tables dealing with the process variables (plating solutions, time, bath temperature, current, etc.) are included.

Low Temperature Specific Heat of Indium and Tin,* C. A. Bryant and P. H. Keesom,** *The Physical Review,* **123,** 491-499 (July 15, 1961).

The heat capacities of indium and tin were measured between 0.4 and 4.2°K. In the normal state, the specific heat could be represented by $AT^{-2}+\gamma T+\alpha T^3+\beta T^5+\mu T^7$. For Sn, in molar millijoule units, $A=0$; γ, the coefficient in the electronic term, is 1.80; $\alpha=0.242$, corresponding to a Debye Temperature, θ_0, of 200°K; $\beta=0.004$; and $\mu=0.00014$. For In, A, the coefficient of a nuclear electric quadrupole term, is calculated to be 8.97×10^{-4} from resonance data; $\gamma=1.61$ for one ingot and 1.59 for another; $\theta_0=109$ and 108°K; and $\beta=0.008$. In the superconducting state, the specific heat of Sn could be expressed as the normal lattice term plus an electronic term of the form $a\gamma T_c \exp(-bT_c/T)$, with $T_c=3.70$°K (0.02 deg. lower than found in a magnetic measurement), $a=7.63$, and $b=1.41$ when $2<T_c/T<7$; the value of b agrees with infrared measurements of the energy gap. This sort of analysis could not be applied to In, for below 0.8°K, the total superconducting specific heat was less than the normal lattice term.

A possible interpretation is that θ_0 is 9% higher in the superconducting state than in the normal metal at 0.4°K; this is not supported, however, by the recent acoustic measurements of the elastic constants by Chandrasekhar and Rayne. The anomaly is not as yet understood, but a few plausible explanations are discussed.

*Work supported by a Signal Corps Contract.
**Purdue University. On leave of absence at the Kamerlingh Onnes Laboratory, Leiden University, Leiden, The Netherlands.

Low Temperature Specific Heat of Molybdenum,* C. A. Bryant and P. H. Keesom,** *Journal of Chemical Physics,* **35,** 1149-1150 (September, 1961).

Electronic and lattice specific heats of two molybdenum specimens are reported for liquid helium temperatures.

*Work supported by a Signal Corps Contract.
**Purdue University. On leave of absence at the Kamerlingh Onnes Laboratory, Leiden University, Leiden, The Netherlands.

Magnetic and Thermodynamic Properties of Potassium Ferricyanide at Low Temperatures, L. V. Gregor and J. J. Fritz,* *Journal of the American Chemical Society,* **83,** 2832 (July 5, 1961).

The heat capacity and magnetic susceptibility of potassium ferricyanide have been measured from 0.6° to 20°K. There is a small peak in the heat capacity below 2°K whose maximum is at 1.2°K, and X_mT decreases sharply below 2°K. The magnetic susceptibility follows a Curie-Weiss law between 20° and 2°K. The entropy removed by isothermal magnetization to 7040 oersteds at 1.245°K is 0.122 eu. Adiabatic demagnetization from this point lowered the temperature to 0.52°K.

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The Measurement of Cathode Electron Temperature Utilizing an AC Retarding Potential Device, A. D. Wilson, *Report on the Twenty-First Annual Conference, Physical Electronics,* March 29-31, 1961,* Massachusetts Institute of Technology, 242-261.

An ac retarding potential technique for measurement of the cathode temperature is developed. The theory of the measurement, which assumes a Maxwellian distribution of the exit velocities of the emitted electrons, is discussed. Procedure of measurement, interpretation of typical results, and limitations of the device are investigated.

The electron temperatures of oxide cathodes and matrix cathodes are measured and show good correspondence with the thermodynamic temperature. A maximum difference of 20°K exists between the electron and thermodynamic temperatures for the two cathodes studied. No explanation is given for this difference in the two temperatures.

*For period January 1 through March 31, 1961.

Molecular Weight Distribution from the Normal Coordinate Theory of Viscoelasticity, E. Menefee* and W. L. Peticolas, *The Journal of Chemical Physics,* **35,** No. 3, 946-950 (September, 1961).

The normal coordinate theory of viscoelasticity has been shown to provide a bridge between the measurable rheological properties of linear polymers and their molecular-weight distribution functions, as well as their average molecular weights. Equations have been derived relating the molecular-weight distribution function of a linear polymer to a sum of functions of a measurable rheological property such as stress relaxation or dynamic viscosity. Thus, a method for the simple and rapid determination of molecular weight distribution has been developed within the limitations of the normal coordinate theory.

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Molecular-Weight Dependence of the Viscoelastic Properties of Whole Polymers, W. L. Peticolas and E. Menefee,* *The Journal of Chemical Physics,* **35,** No. 3, 951-954 (September, 1961).

A method has been developed by which it is possible to determine the type of molecular weight averaging upon which viscoelastic properties of polymers may depend and which may be used to verify the normal-coordinate theory of viscoelasticity for various type of polymers. The method is extraordinarily simple to carry out since is involves only measurement of the property on whole polymers and mixtures of whole polymers. Neither fractionation nor molecular-weight measurements themselves are required.

Methods of determining the correct average-molecular-weight dependence of melt viscosity and steady-state elastic compliance have been worked out in detail and are illustrated with data on linear polyethylenes.

The method is also applicable to other polymer properties which are molecular-weight dependent.

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Multiple-Collector Semiconductor Devices in Molecular Electronics, D. P. Kennedy and S. Gilman,* *Electrical Engineering,* **80,** No. 7, 516-523 (July, 1961).

A theoretical analysis is presented on the operation of a computer logic component exhibiting current commutation between two hook collectors. A quantitative theory is established for the current-multiplying hook collector and for many factors contributing to the interaction between such collectors. Appropriate equations are presented in graphical form throughout a range of physical and geometrical parameters encountered in the design of a typical 2-collector structure.

*General Electric Co., Schenectady.

A Nomogram for the Solution of Quadratic Equations, M. E. Arthur, *Machine Design,* **33,** 194-195 (September 14, 1961).

A nomogram for solving the quadratic equation in the form $x^2+bx+c=0$ is presented. Along with an explanation of its use, a means for extending the useful range of the nomogram is given.

Non-Equilibrium Statistical Mechanics, E. W. Montroll, *Lectures in Theoretical Physics, III,* 221-325, Interscience Publishers (1961).

This is a set of lectures on recent developments in non-equilibrium statistical mechanics as presented to the 1960 Summer Institute for Theoretical Physics at the University of Colorado, Boulder, Colorado.

Note on the Polishing of Small Spheres of Ferrimagnetic Materials, J. G. Grunberg,* G. Antier,* and P. E. Seiden,** *Review of Scientific Instruments,* **32,** No. 8, 979-80 (August 1, 1961).

A method is described for providing high surface polishes on small spheres in relatively short times. Polishing times of 1-2 hours are sufficient to obtain polishes needing as long as three days with conventional tumbling techniques.

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A Note on the System Design of a Digital Computer for the Manipulation of List Structures, H. L. Gelernter, *IRE Trans. on Electronic Computers,* **EC-10,** No. 3, 484-489 (September, 1961).

The technique of programming within the framework of the so-called Newell-Shaw-Simon (NSS) associative list memory is currently the subject of much interest among workers in the area of advanced programming research. Unfortunately, committing a given program to list memory generally entails accepting a significant loss of speed and efficiency in information processing, so that the advantages accruing from the use of list memory must be carefully balanced against its weaknesses. This paper is concerned with the system requirements of a digital computer for which the use of list techniques is to be competitive with standard programming, so that the particular memory organization for a given problem may be chosen on the basis of suitability and ease of programming alone. A description of a list-processing, 7090-type computer is appended in order to make our discussion concrete, although engineering and economic feasibility is not implied.

Nuclear Quadrupole Resonance and Electron Spin Resonance in $C(NH_2)_3$ $Al(SO_4)_2 \cdot O$ and Isomorphous Compounds, G. Burns, *Physical Review,* **123,** No. 5, 1634-1644 (September 1, 1961).

The temperature dependence of the nuclear quadruple coupling parameters, eQq/h, of Al and Ga has been measured in the ferroelectric compound $C(NH_2)_3AlSO_4 \cdot 6H_2O$ (GAlSH) and three other isomorphous compounds that result when Ga replaces Al and SeO_4 replaces SO_4. Measurements were also made on deuterated GAlSH. The temperature dependence of the electron spin resonance (ESR) of Cr^{3+}, substituted for Al or Ga in the above five compounds, was also measured. For the five compounds, eQq/h versus temperature for each compound was similar, small (~100 kc/sec), linear with temperature and in some cases changed sign. Within the framework of the ionic model, eQq/h and $d(eQq/h)/dT$ have been calculated. It is found that the latter is fairly insensitive to the x-ray and charge distribution parameters and depends mainly on the large anisotropic thermal expansion coefficient. Using the theoretically calculated antishielding factor, there is agreement between the calculated and the measured $d(eQq/h)/dT$. The data also indicate that the ratio of the antishielding factors of Al^{3+} and Ga^{3+} are in approximate agreement with the calculated values.

The temperature dependence of the electron spin resonance of Cr^{3+} in the five compounds is again similar to each other. The g values for the Al and Ga compounds are the same within experimental error. The zero-field splitting (D term in the spin-Hamiltonian) of the deuterated GAlSH has a slightly larger variation with temperature than the undeuterated compound. By parametrically eliminating temperature, the relation between D and eQq/h is studied. The result is two parallel lines, one for the two different sites in the two Al compounds and the other for the Ga compounds. The lines are parallel only if the Ga nuclear quadruple moment and antishielding factor is normalized to those of Al. Using simple crystal field theory, it is shown that D should be proportional to eQq/h. However, the data show that D and eQq/h are not simultaneously zero and that the slope is ten times larger than calculated. These two discrepancies are discussed. A calculation of the extra potential seen by the $3d$ electrons, due to the fact that the crystal field induces a quadrupole moment in the core electrons, is discussed. However, it does not remove the discrepancy. It appears that the relation between D and the crystalline field is not firmly established.

On the Multidimensional Prediction and Filtering Problem and the Factorization of Spectral Matrices, E. Wong and J. B. Thomas,* *Journal of Franklin Institute,* **272,** No. 2, 87-99 (August, 1961).

Since the linear prediction and filtering of multiple-correlated stationary random signals involves the solution of a matrix integral equation, several methods of solution of this equation have been developed. In this paper the direct solution by complex variable techniques is extended from the one-dimensional case. The problem reduces to the factorization of a spectral density matrix and this factorization is the principal topic of the paper.

Under very general conditions, a factorization procedure has been developed by Wiener and Masani for discrete time series. Their technique is applied here with some modifications to the factorization of the spectral density matrices of continuous processes. A simplified procedure is developed also for the case where the elements of the spectral density matrix are rational functions of frequency. Examples illustrate the general technique and the simplified procedure.

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Performance Review—A Method of Controlling Indirect Effort, W. L. Balk, *Journal of Industrial Engineering,* **13,** No. 3, 205-209 (May/June, 1961).*

The author suggests methods other than traditional *work measurement* as a means of evaluating indirect effort. The performance review method outline requires a large amount of participation by operating management. This system requires creative thinking at all levels. It is not a *score-keeping* but rather a basis for self-controlled action at each management level to reduce costs.

*For period April through June 30, 1961.

A Preliminary Study of Fixed-Bed Tubular Catalytic Reactor Dynamics on an Analog Computer, H. D. Yoo, *Instruments and Control Systems,* **34,** 1274 and 1276, (July, 1961).

Experience gained during the process analysis study of a complex physical system is described. A brief discussion of the system, an approach to the problem, and analog simulation technique is given to conclude that a careful examination must be made in each case, in constructing complex models of physical systems.

The Preparation and Properties of Some II-V Semiconducting Compounds, G. A. Silvey, V. J. Lyons and V. J. Silvestri, *Journal of the Electrochemical Society,* **108,** No. 7, 653-658 (July, 1961).

The methods of purification and single crystal growth of six II-V semiconducting compounds are discussed and crystallographic data are presented. The six compounds, representing three stoichiometries, are Cd_3As_2, $CdAs_2$, CdSb, Zn_3As_2,

$ZnAs_2$, and ZnSb. The compounds are thermally dissociated in the vapor phase, and the solid-vapor equilibria of four of the compounds have been measured. Because of the thermal instability, crystal pulling was carried out in sealed quartz tubes employing magnetic suspension of the seed. Through purification of the elements and single crystal growth, high purity was attained in most of the compounds. The highest purity is represented in $CdAs_2$ with an electron carrier concentration of 5×10^{14} cm^{-3}.

The Pressure Dependence of Tunneling in Esaki Diodes, M. I. Nathan and W. Paul,* *Proceedings of the International Conference on Semiconductor Physics, Prague,* 1960, 209-212, Publishing House of the Czechoslovak Academy of Sciences (1961).

The effect of hydrostatic pressure on the current-voltage characteristics of Ge, Si, GaAs and GaSb Esaki diodes is reported. The expected exponential dependence of tunneling current on energy gap is confirmed. A subsidiary relation between tunneling current density and its pressure coefficient is found to hold for Si diodes but to fail for GaAs diodes.

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Quantitized Probability Design: Part I, Richard B. Hurley, *Electronic Equipment Engineering,* **9,** No. 9, 51-54 (September, 1961).

Technique for designing transistor logic circuits is based on statistical probability. A set of quantized rules is used for the actual design, and statistical methods are used only for checking.

The Radiotracer Testing Method in Metal Cleaning Studies, G. D. Fatzer and B. E. Blake, *International Journal of Applied Radiation and Isotopes,* **10,** 167-176 (July, 1961).

A prerequisite for obtaining reproducible results from friction, wear and resistance studies of rubbing surfaces is reproducible cleanliness of the metallic samples. Contamination of the wear samples by organic lubricants (long-chain fatty acids and their derivatives) and by products from a cleaning procedure will give data which is inherently widespread.

This paper describes radiotracer studies for testing the effectiveness of several cleaning techniques. The contamination of metallic surfaces (copper, gold) with $S^{35}O_4^=$, $Cr^{51}{}_2O_7^=$ and C-14 fatty acids (palmitic, stearic) was investigated. The detection sensitivities for $S^{35}O_4^=$, Cr^{51}, palmitic and stearic-1-C 14 acids were respectively 3×10^{-8}g, 1.5×10^{-7}g, 3.2×10^{-9}g, and 6.2×10^{-10}g. Results obtained show that when copper surfaces were anodically electro-cleaned, less than 3×10^{-8}g $SO_4^=$ and less than 1.5×10^{-7}g of Cr remained on the copper samples.

Toluene and chromic acid were found to be excellent cleaning agents for fatty acids. The quantity of fatty acid remaining on copper substrates after three successive immersions in toluene averaged 0.01 to 1 monolayer, depending on the amount of the contaminant originally present. Less than 3×10^{-9}g of palmitic acid (i.e., 1.6×10^{-2} monolayer), or 6×10^{-10}g of stearic acid (i.e., 3×10^{-3} monolayer), remained on gold and copper surfaces after anodic polishing in chromic acid at 120° C for two minutes.

Rb^{85}–Rb^{86} Hyperfine-Structure Anomaly, Norman Braslau,* Gilbert O. Brink, and Jhan M. Khan, *Physical Review,* **123,** No. 5, 1801-1811 (September 1, 1961).

The atomic beam magnetic-resonance method with separated oscillatory fields has been used to measure the hyperfine structure separation and magnetic dipole moment of the isotopes Rb^{85} and 18.6-day Rb^{86} in the $^2S_{1/2}$ electronic ground state. Observation of the separation of a $\Delta F = \pm 1$ doublet in the intermediate field region gives the value of the moment; the minimum value of the mean doublet frequency gives the value of $\Delta\nu$. Observation of another $\Delta F = \pm 1$ doublet in low field also yields a value for $\Delta\nu$.

Results obtained for Rb^{85} are in good agreement with previously published values and indicate that transition frequencies calculated from the Breit-Rabi equation agree with experiment to at least one part per million.

For Rb^{86} the following values are obtained for the $^2S_{1/2}$ ground state: $\Delta\nu = 3946.883(2)$ Mc/sec, $g_I = -4.590(4) \times 10^{-4}$, and $\mu_I = -1.6856(14)$ nm (without diamagnetic correction).

The hyperfine-structure anomaly arises in part from the difference of the volume distribution of nuclear magnetism in the two nuclei and is defined as the deviation from equality of the ratio of the hyperfine-splitting factors of two isotopes to the ratio of their nuclear g factors. For these two isotopes its value is found to be $^{85}\Delta^{86} = 0.17(9)\%$.

The Bohr-Weisskopf theory of the hfs anomaly is applied to these isotopes with calculations based on a single-particle model with varying distributions of spin and orbital contributions to the magnetic moment.

*This work was done while the author was at the Lawrence Radiation Laboratory, University of California, Berkeley.

RFI – Its Effect on Computers, J. A. Harder and R. L. Powers, *Electronic Equipment Engineering,* **9,** No. 7, 63-65 (July, 1961).

Errors in operation of digital computers can be caused by high intensity radio-frequency interference from external sources. Tests show susceptibility of solid-state computer in comparison with previously tested vacuum-tube systems.

Simple Transistor Tester Uses Lamp for Indicator, E. H. Sommerfield, *Electronics,* **34,** No. 36, 80 (September 8, 1961).

This paper describes a portable transistor tester with simplified circuitry. It features a "Go-No-Go" test circuit utilizing lamp indication that provides a clue to the type of junction failure, if any, in addition to a standard DC amplification test. The tester was designed to fill the need for a simple device that would indicate, in one operation, whether a device has experienced a catastrophic failure and, if not, whether it is capable of providing a minimum device gain. A table of test conditions is given, and a diagram of the circuitry is shown.

The Simulation of Three Machines which Read Rows of Handwritten Arabic Numbers, L. A. Kamentsky,* *IRE Transactions on Electronic Computers,* **EC-10,** No. 3, 489-501 (September, 1961).

Three machines have been simulated using an optical scanner and the IBM 704 computer. Each of these simulated machines has read documents containing rows of handwritten Arabic numbers. Sample numbers were produced by at least 20 people for each simulation study. The three machines simulated differ in the control required of the writer during document preparation and in the complexity of the machines. Writing controls were required for the preparation of the first two types of documents. A section of this paper concerns

experiments with, and a mathematical model of, controlled writing. The third simulated machine was applied both to numbers written within preprinted boxes and to numbers written without any guide marks. About one per cent of 2180 of these numbers were misread as the wrong character. This error rate is based on a sequential experiment in which the recognition logic is constructed from all characters not recognized and thus rejected prior to each input character. Numbers, when rejected, cause the program to identify them from a table. Their structure is then entered into the recognition logic. The rejection rate decreased throughout the experiment. The last rejection rate was about 10 per cent.

*Work performed while author was at Bell Telephone Laboratories.

Size Effects in Thin Superconducting Indium Films, A. M. Toxen, *The Physical Review,* **123,** No. 2, 442-446 (July 15, 1961).

Measurements of residual resistivity, superconductive critical temperature, and critical magnetic field have been carried out on indium films ranging in thickness from 650 to 126,000 A. The thickest films had the bulk critical field and critical temperature. The variation of residual resistivity with thickness is consistent with Fuchs' model if one assumes an intrinsic resistivity, ρ_0, of 1.31×10^{-8} ohm cm and an intrinsic mean free path l_0 of 152,000 A. The value of $\rho_0 l_0$ so obtained was 2.0×10^{-11} ohm cm^2. The critical temperature was found to be a systematic function of film thickness, increasing with decreasing thickness. The magnitude of this change in critical temperature is in good agreement with a simple model relating critical temperature to elastic stresses in the films. The penetration depth, as calculated from the critical field by means of the London theory or the Ginzburg-Landau theory, was found to increase with decreasing film thickness. This result is consistent with a nonlocal model and implies a coherence length of approximately 2600 A.

Studies of Color Centers Produced in Apatite Halophosphates by Shortwave Ultraviolet Radiation,* Lawrence Suchow, *Journal of the Electrochemical Society,* **108,** No. 9, 847-851 (September, 1961).

An investigation has been made of the effects of shortwave ultraviolet radiation on nonluminescent base materials, in which it is possible to isolate other electronic processes from those of luminescence. This radiation has been found to produce color centers in a typical commercial halophosphate base material, in a similar preparation with manganese present in addition, and also in compounds and solid solutions in the systems $Ca_5(PO_4)_3$ F-$Ca_5(PO_4)_3$ Cl, $Sr_5(PO_4)_3$ F-$Sr_5(PO_4)_3$ Cl, and $Ba_5(PO_4)_3$ F-$Ba_5(PO_4)_3$ Cl. All colors may be bleached thermally and some optically as well. In preparations containing strontium, thermal bleaching is accompanied by luminescence, and glow curves have been measured. Optical bleaching is also accompanied by luminescence.

*Work done at Westinghouse Electric Corporation, Lamp Division Research Department, Bloomfield, New Jersey.

Superconducting Computers, W. B. Ittner, III and C. J. Kraus, *Scientific American,* **205,** No. 1, 125-136 (July, 1961).

The demand for computers of greater capacity calls for smaller and faster computer elements. One approach to the problem is to design elements that take advantage of the phenomenon of superconducitvity.

Surface Energy Effect on Diffusion-Controlled Particle Growth, G. A. Somorjai, *Journal of Chemical Physics,* **35,** No. 2, 655-658 (August, 1961).

A theory of diffusion- and surface-energy-governed particle growth is presented for spherical precipitates in solids. The high surface energy of small particles retards the growth in the initial stage of the process. For large particles the limiting case is the diffusion-controlled growth as the surface-energy contribution becomes negligible.

Surface Layers on Barium Titanate Single Crystals above the Curie Point, H. Schlosser* and M. E. Drougard, *Journal of Applied Physics,* **32,** No. 7, 1227-1231 (July, 1961).

Dielectric dispersion measurements have been carried out on barium titanate single crystals of different thicknesses at temperatures above the Curie point ranging up to 180°C. In the high-frequency range of the measurements (100 kc), the measured dielectric constant of thin crystals is consistently much smaller than that of thick samples. The effect is ascribed to the presence of a layer of low dielectric constant on the surface of the crystals, with a capacitance of the order of 0.5 μf/cm^2 in the temperature range explored. The relaxation time of this surface layer is found to be at least 10^{-4} sec at 120°C on crystals which have not been aged recently.

*Present address: General Telephone and Electronics Laboratories, Inc. Work performed at IBM as a summer employee.

Tendenzen in der Datenspeicherung (Trends in Data Storage), Editorial, A. P. Speiser, *Elektronische Rechenanlagen,* **3,** No. 4, 143 (August, 1961).

High-speed storage is now predominantly done with cores. For the near future thin films seem most promising whereas tunnel diodes and cryogenic memories are more remote. For high capacity storage, photo memories offer important opportunities. In the field of memory organization the associate memory is one of the more important developments.

A Test for the Validity of the Rouse-Ferry Equation,* J. E. Eldridge** and W. L. Peticolas, *Journal of Polymer Science,* **51,** No. 156, S35-S38 (June, 1961).†

A method for testing the validity of the equation of Rouse and Ferry, which predicts the dependence of the steady-state elastic compliance on certain average molecular weights, is described. The test is remarkable because no measurement of average molecular weights is required.

*Written while Dr. Peticolas was employed by E. I. duPont Nemours & Company.
**E. I. duPont Nemours & Company.
†For period April 1 through June 30, 1961.

Thermal Effects in Urea: The Crystal Structure at −140°C. and at Room Temperature, Natalie Sklar, Michael E. Senko, and Ben Post, *Acta Crystallographica,* **14,** 716-720 (July, 1961).

The crystal structure of urea has been analyzed on the basis of (hOl) and (hkO) data obtained at room temperature and at −140°C. Fourier and least-squares methods were used. Results generally agree well with those previously reported by Vaughan & Donohue (1952), but several of the atomic temperature factors differ significantly from those reported

by Worsham, Levy & Peterson (1957) on the basis of neutron diffraction measurements.

Coefficients of thermal expansion have been measured, and changes in atomic coordinates, bond lengths and angles with temperature have been computed. The only major dimensional change with temperature involves the inter-molecular hydrogen bond lengths which decrease considerably with decreasing temperature, resulting in a corresponding decrease in unit cell dimensions.

Thermal Variation of the Pitch of Helical Spin Configurations, M. J. Freiser, *Physical Review,* **123,** No. 6, 2003-2012 (September 15, 1961).

When the method of Luttinger and Tisza for finding the classical ground state of a system of spins with Heisenberg interactions is applicable, it yields a configuration with the same periodicity as the ordered state existing just below the transition temperature. When the method of Luttinger and Tisza fails to yield the classical ground state, then there can occur, with decreasing temperature, either additional transitions or a gradual change in the periodicity of the stable configuration. An example of the latter is the thermal change in pitch of a helical configuration. Such a situation can be described in the internal field approximation when the consistency equations admit as solutions helical states with a continuous range of pitches. The free energy of the stable state with a temperature-dependent pitch can then be obtained as the envelope of the free-energy curves belonging to the family of helical solutions. A one-dimensional diatomic chain whose ground state can be found by a generalization of the method of Luttinger and Tisza illustrates this possibility. It is also pointed out the anisotropic exchange interaction between nearest neighbors can give rise to helically ordered configurations.

Transistor Power Dissipation in High-Speed Switching Circuits, G. C. Georgallis, *Electrical Design News,* **6,** No. 8, 84-85 (August, 1961).

In a transistor switch operating at a high prf, transient power dissipation may be a large portion of the total allowable power. The procedure described in this paper may be used to find a close approximation of transient dissipation. With this information, it is possible to determine the total power being dissipated by the transistor.

Sub-Solidus Equilibria in the System Nb_2O_5-Ta_2O_5, F. Holtzberg and A. Reisman, *Journal of Physical Chemistry,* **65,** 1192 (January 12, 1961).

Phase equilibria in the system Nb_2O_5-Ta_2O_5 have been reinvestigated using thermal analysis and X-ray techniques. The results are not in agreement with Schafer, Durkop and Jori's proposed diagram, which shows a continuous series of homogeneous solid solutions. A compound formed above 1450°, having the composition $2Nb_2O_5 \cdot Ta_2O_5$, has been indexed on the basis of a body-centered-cubic unit cell with $a_0 = 15.76$ A. Below 1450°, the compound decomposes sluggishly to form a two-phase region extending from 25-51 mole % Ta_2O_5. An explanation is offered to account for the apparent reversibility of Nb_2O_5 phases reported by Schafer, et al.

*For period January through March 31, 1961.

A 2.18-Microsecond Megabit Core Storage Unit, C. A. Allen, G. D. Bruce, and E. D. Councill, *IRE Transactions on Electronic Computers,* **EC-10,** No. 2, 233-237 (June, 1961).*

A magnetic core memory is described which has a read-write cycle time of 2.18 microseconds, an access time of 1.0 microseconds, and a storage capacity of 1,179,648 bits. The array configuration and the design of the driving system are shown. The core and transistor requirements are discussed, and a description is given of the sensing and the driving circuitry. Design factors which governed the choice of the 3-dimensional system organization are presented.

*For period April through June 30, 1961.

Vibration of an Elastic Globe with a Homogeneous Mantle over a Homogeneous Core, Vibrations of the First Class, Y. Sato and T. Matumoto,* *Journal of the Physics of the Earth,* **9,** No. 1, 1-16 (March 31, 1961).**

Torsional oscillation of the earth having a homogeneous mantle and core is studied theoretically, and it is concluded that: (1) Existence of the core with large rigidity makes the frequency of oscillation higher. (2) Existence of the core with small rigidity decreases the frequency of fundamental mode and the period becomes very long. (3) However, when the core rigidity is small, there are higher modes whose periods are nearly equal to those in the case of the perfect liquid core, and the feature of motion in the mantle is also similar. (4) Although the displacement in the core for this case is very large and is completely different from the case of perfect liquid, the observed period will be the one for these modes with undeveloped displacement distribution in the core.

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